UNIT 1

Description of Motor Vehicle

Structure

1.0 Introduction
1.1 Vehicle
1.2 Major assemblies

Learning objectives

After learning this unit you will be able to

• Know about vehicles.
• Known about classification of vehicle.
• Know about major assemblies

1.0 Introduction

World’s first three-wheeled automobile with of to cycle petrol engine was built by Karl Benz of Germany in 1885 the first American Car with a petrol engine in said to have been designed in 1877 by George Baldwin seldom of Rochester. Large scale production-line manufacturing of automobiles was started by ransom Eli olds in 1902.

1.1 Vehicle

A vehicle producing power within itself for its propulsion is known as a self-propelled vehicle e.g. Moped, scooter, motor cycle, Car, Tractor, Bus, truck motor boat, hip aeroplanes etc.
1.1.1 Classification of Vehicle

There are in general three main classification of the various types of vehicles

1. The single unit vehicles or load carriers
2. Articulated vehicle
3. The heavy tractor vehicle
1.2 Major assemblies

The main units of an automobile are

1. The basic structure
2. The power plant
3. The transmission system
4. The auxiliaries
5. The controls
6. The super structure

1.2.1 The basic structure

This is the unit on which are to be built the remainder of the units required to turn it into a power operated vehicle. It consists of the frame, the suspension system, axles, wheels, and tyres.

1.2.2 Frame

There are two distinct forms of construction in common use

1. The conventional pressed steel frame to which all the mechanical units are attached and on which the body is super imposed.
2. The integral or frame less construction in which the body structures is so designed as to combine the function of body and frame, the units normally attached to the frame then being attached directly to the body.

1.2.3 Suspension system

The objects of suspension are

1. To prevent the road shocks to the vehicle components
2. To preserve the stability of the vehicle impitching or rolling, while in motion.

Types of suspension system

1. The conventional system
2. The independent system

1.2.4 Axles

The weight-carrying portions of the axles, whether it may be front or rear, may be considered as beams supported at the ends loaded at two intermediate points.
Types of rear axles

1. Fully floating type
2. Three-quarter floating type
3. Semi-floating type

1.2.5 Wheels

A wheels consist of a central flanged disc pressed into the rolled section rim and retained in position by welding light alloy wheels are currently used in luxury cars they are called “Formula wheels”. Wire-spoked wheels have been used mainly in sports cars because their light weight and quickness in changing the wheel.

1.2.6 The power plant

The power plant in the engine in the vehicle provides the motive power for all the various function which the vehicle or any part of it the power plant generally consist of an internal combustion engine which may be either of spark ignition, or of compression ignition type.

Types of the power plant (Engines)

1. I.C Engine
2. Gas turbine engine
3. Electric motors powered by batteries
4. Combination of an I.C engine and electric motor
5. Solar energy - powered engines
6. Fuel cells-used engines

1.2.7 The transmission system

The transmission system consist of a clutch gear base, Bevel pinion and crown wheel, universal joints, Differential functions of the transmission system.

1. To disconnect the engine from the road wheels when desired.
2. To connect the engine to the driving wheels without shock.
3. To reduce the engine speed permanently in a fixed ration.
1.2.8 The Auxiliaries

It is common to almost all types of vehicle is the electrical equipment this can be sub divided into four system.

(a) Supply system – Battery and generator
(b) The starter
(c) The ignition system – Battery and magneto ignition
(d) Ancillary devices

1. Driving lights – head, side, tail lights etc
2. Signaling – Horn direction indicators etc
3. Other lights – Interior roof lights etc
4. Miscellaneous : Radio, fans etc

1.2.9 The controls

The controls consist of

1. Steering system
2. Brake

1.2.10 The super structure

In those cases, where frame less construction is not adopted there must be a separate superstructure i.e. The body attached to the frame while in case of Frame less construction the body performs the function of both. The body consist the passenger and the luggage space besides the engine compartment.

Summary

- An automobile is a wheeled vehicle carrying its own motive power unit
- Suspension system prevent the rod shocks to the vehicle components
- Wire-spoked wheels have been used mainly in sport cars.
- Engine is the power plant for vehicle

Short Answer Type Questions

1. Define vehicle.
2. Write the major assemblies in vehicle.
3. Write about classification of vehicle.
Long Answer Type Questions

1. Explain the major assemblies in vehicle.
2. Explain the basic structure of the vehicle.

O.J.T

1. Study the assemblies in vehicles.
2.0 Introduction

In order to draw the automobile on the road easily with lesser force of friction between the vehicle and road an air bag or inner tube contained in a cover causing the vehicle to float on air cushion was made. Modern tyre provides better adhesion between the road and wheels for satisfactory grip for steering and braking. A tyre is a band of iron, steel, rubber etc placed round the rim of a
wheel to strengthen it and reduce vibration. The pneumatic tyre was invented in 1848 by a Scottish civil engineer R.W Thomson. It was reinstated by J.B Dunlop, a Belfast veterinary surgeon in 1888 for bicycles.

2.1 Description of Wheels

Without the engine the car may be towed but even that is not possible. Without the wheels the along – with tyre has to take the vehicle load, provides a cushioning effect and cope with the steering control. The various requirement of an automobiles are:

1. It must be strong enough to perform the above function
2. It should be balanced both statically as well as dynamically
3. It should be lightest possible so that the un spring weight is least
4. It should be possible to remove or mount the wheel easily.

Types of Wheels

There are three types of wheels

1. Disc wheels
2. Wire wheels
3. Light alloy cost or forged wheels

Disc Wheels: This type of wheel consist of two parts, a steel rim and a disc the rim and the disc may be integral permanently attached.

Wire Wheel: The wire wheel has a separate hub, which is attached to the rim through a number of wire spokes. Each spokes is individually hooked at one end of the hub while its other and is pushed through a hole in the wheel rim, where a tapered nut, called nipple, is screwed down pulling the spoke tight.

The advantages of this type wheel are

1. Light weight
2. High strength
3. Provides better cooling to the brake drum
4. Easy to change the wheel when required

Disadvantage in the wire wheels are very expensive and not suitable for tubeless tyres.
Light alloy cost or forged wheel

The wheels made from aluminum or magnesium alloys. Cast wheels are generally used for cars while forged wheels are preferred for heavier vehicles the main advantage of light alloy wheel weight about 50 percent of a steel wheel and about 70 percent of an aluminum alloy wheel for similar strength. Light alloys are better conductor of heat which helps the wheel dissipate any heat generated by the tyres or brakes and thereby run cooler.

2.2 Tyre

A tyre is a cushion provided with automobile wheel. It consist of mainly the outer cover i.e. the tyre proper and the tube inside the tyre – tube assembly is mounted over the wheel rim. It is the air inside the tube that carries the entire load and provides the cushion.

2.2.1 Function of the tyre

1. To support the vehicle load
2. To provide cushion against shocks
3. To transmit driving and braking forces to the road
4. To provide cornering power for smooth steering

2.2.2 Tyre properties

1. Least amount of skidding even on wet road
2. Uniform wear
3. The tyre must be able to sustain the stresses
4. The tyre should be able to absorb small high frequency vibration
5. Power consumption must be less
6. Noise should be minimum
7. It must be balanced statically as well as dynamically.

2.2.3 Types of Tyres

Tyres may be classified according to the following consideration.

1. Basic construction
   (a) Conventional tubed tyre
   (b) Tube less tyre

2. Use
   (a) All-season tyres
   (b) Summer tyres
   (c) Wet-weather tyres
   (d) Snow/ice tyres
   (e) All-terrain tyres

3. Ability to run flat
   (a) Self-sealing tyres
   (b) Self supporting tyres
   (c) Auxiliary – supported tyres

2.2.4 Causes of tyre wear
1. Incorrect inflation
2. Incorrect caster, camber or toe-in
3. Excessive road speed
4. Excessive braking
5. Worm out steering mechanism
6. Worm out king pin
7. Misalignment of wheel
8. Out of balance wheel
9. Defective brakes
10. Over loading

2.2.5 Effect of air pressure on tyre performance

(i) On dry road: Only properly inflated tyres provide quick response and good handling. The under inflated tyres required more steering input to initiate man covers and are slower to respond. Besides under inflated tyres also feel out of synchronization during transitions i.e. instead of moving in unison the rear tyres reaction lag behind those of the front tyre resulting in a detached sensation being transmitted to the drivers.

On wet road: A significantly under inflated tyre would alloy the centre of the tread to collapse and become very concave tapping water rather than allowing it to flow through the tread design. Thus the driving the vehicle with the under inflated tyres would be more difficult and would force the driver to slow down the retain control.

Effect of Temperature on tyre pressure

The tyre pressures recommended by the vehicle manufacture are the cold inflation pressure which means the tyre pressure is to be measured and maintained in the morning.

As a rule of thumb for every 5°C increase in air temperature tyres inflation pressure would increase by about 1 psi (7kpa) and vice versa.

Inflation

The tyres must be inflated according to the specification of the original vehicle manufactures table gives the tyre pressure recommended by some of the on the indian automative manufactures.

Recommended tyre pressure

<table>
<thead>
<tr>
<th>S.No</th>
<th>Car</th>
<th>Inflation pressure psi (kpa)</th>
<th>Front tyre</th>
<th>Rear tyre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Maruti (Suzuki)</td>
<td>26 (180)</td>
<td>26480</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Fiat /premier president</td>
<td>24(160)</td>
<td>24(160)</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Standard Herald</td>
<td>22 (150)</td>
<td>24(160)</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Ambassador</td>
<td>26(180)</td>
<td>28(190)</td>
<td></td>
</tr>
</tbody>
</table>
Both the under inflation as well as the over inflation are detrimental to 

  tyre life. The main effects of over inflation are.

  (i) Rapid wear of tyre tread in centre only
  (ii) Over inflation causes excessive tension in the tyre. It increased 
       tendency for concussion breaks .
  (iii) Ab normal stresses and strains in the tread area. Causing tread 
        separation ply separation over tread cracking
  (iv) Harsh ride because of reduction in the cushioning effect
  (v) Decreased resistance to skidding

  On the other hand the effects of under inflation or

  1. Under inflation cause the shape of the side wall cracking or loose 
     cords inside tyre casing or ply separation.
  2. More tread wear on the sides than in the centre.

  Carrying capacity : In case of over loading the tyre has in sufficient 
  amount of air support the dead weight carried and the results of over bading , 
  therefore are the same as described above for under inflation the over loading 
  results in decrease of tyre mileage. The only remedy for this is to fit a larger tyre 
  with adequate loading capacity , provided the rim used is also of correct width 
  and sufficient strength.

  2.2.6 Construction of tyre

  A tyre may have a conventional cross-ply construction or a radial ply 
  construction the fig shows the important components of a tyre or the casing 
  bead and treat the strength of the tyre in based on the construction of the casing. 
  Casing of a tyre is made upof four or six layers of fabrics.

  A tyre is made up of four or six layers of fabric. In each layer a sheet of 
  series of rubberized is cards by lying them side by side. By placing each sheet at 
  a given angle to the adjacent layer a strong casing is produced. The tyre 
  characteristic are governed by this angle. Previously cotton was used as the 
  main material but now-a-days rayon or nylon having stronger fibers and offering 
  greater resistance to the heat set up the flexing of the tyre are employed.

  In order to retain the tyre on the rim, a bead having a number of hoops 
  of steel wire in used . Around the bead wire, the casing is warped and moulded 
  into the shape.
The tread bonds with the soft rubber enclosing the casing. It is made of natural or synthetic rubber compounded with chemicals like carbon black for producing a hard, abrasion-resisting substance. To wipe grease and water off the road, various tread patterns are used, the teeth are formed by the zigzag circumferential grooves biting into the surface by transversely slotting the tyre to form bold tread bars, an excellent grip preferably on soft surfaces can be obtained.

**Summary**

- Wise wheels are light in weight
- Cost wheels are generally used for cars
- Forged wheel are preferred for heavier vehicle
- A tyre is a cushion provided with automobile wheel
- As a rule of thumb for every 5°C increase in air temperature tyres inflation pressure would increase by about 1psi (7kpa)
- A tyre may have a conventional cross-ply construction or a radial ply construction.
Short Answer Type Questions

1. Write the type of wheels.
2. Write the advantages of wire wheels.
3. Explain “Tyre”.
4. Write the functions of the tyre.
5. Write the properties of the tyre.
6. Write the types of tyre.

Long Answer Type Questions

1. Explain plain the types wheels.
2. Write about causes of tyres wear.
3. Write about effect of air pressure on tyre performance.
4. Explain the construction of tyre.

O.J.T

1. Visit the tyres and tube, wheels maintenance shop

Practical Questions

1. Effects of the air pressure on the tyre performance.
2. Give the recommended tyre pressures.
3.0 Introduction

3.1 Functions of steering system

3.2 Requirement of good steering system

3.3 Steering linkage for vehicle with rigid axle front suspension

3.4 Independent front suspension

3.5 Steering gears

3.6 Power steering

3.7 Types of power steering system

Learning Objectives

After studying this unit, you will able to

- Know about function of steering system
- Know about requirement of good steering system
- Know about steering linkages for vehicles
- Know about power steering system
- Know about steering gears
3.0 Introduction

For the effective control of the vehicle throughout its spread range with safety and without much conscious effort on wide variety of road surface providing bumps and bounces to the vehicle proper steering is necessary.

The steering system in addition to directing the vehicle in a particular direction must be arranged geometrically in such a way so that the wheels undergo true rolling motion without slipping or scuffing.

3.1 Functions of steering system

1. To achieve angular motion of the front wheels to negotiate a turn
2. To provide directional stability of the vehicle when going straight ahead
3. To provide perfect rolling motion of the road wheels at all times
4. To facilitate straight ahead recovery after completing a turn
5. To minimize tyre wear

3.2 Requirement of a good steering system

1. The steering mechanism should be very accurate and easy to handle
2. The effort required to steer should be minimum and must not be tiresome to the driver
3. The steering mechanism should also provide directional stability. This implies that the vehicle should have a tendency to return to its straight ahead position after turning.

Steering linkage

There are

1. Steering linkage for vehicle with rigid axle front suspension
2. Steering linkage for vehicle with independent front suspension

3.3 Steering linkage for vehicle with rigid axle front suspension

In the linkage the drop arm (also called pitman arm) is rigidly connected to the cross-shaft of the steering gear at its lower end, while its lower end is connected to the link rod to a ball joint. To other end of the link rod is connected the link rod arm through a ball joint. Attached rigidly to the other end of the link rod arm is the stub axle on which the road wheel is mounted each stub axle has a forged track rod arm. Rigidly bolted to the wheel axis.
The other ends of the track rod arms connected to the track rod by means of ball joints. The design of these ball joints is such that the expanding spring compensates for wear or mis-adjustment. An adjuster is also provided in the track rod to change its length for adjusting wheel alignment.

Fig 3.1 Steering linkage for rigid axle suspension

The steering gear provides mechanical advantage so that only a small effect is required at the steering wheel to apply a much larger force to the steering linkage more ever. More over it also provides the desired velocity ratio so that much smaller movement of the stub axle is obtained with larger angular movement of the steering wheel. When the steering wheel is turned, the swinging action of the drop arm imparts a near linear movement to the link rod. This movement is transmitted through the link rod arm to the stub axle so as to turn the later about its Pivot, which may be a king pin or ball joints. The other wheel is steered through the track rod. Thus only one wheel is positively steered.

3.4 Independent front suspension

In case of conventional rigid axle suspension the main axle beam ensures the movement of stub axle in the horizontal plane only. In this therefore, there is no vertical deflection of the suspension and hence there is no change in effective track-rod length. However in the case of independent suspension the two stub axles can move up or down independent of each other due to which distance between ball-joints ends of the two track and arms in continuously varying on account of this single track rods as in conventional system described above cannot be used.
Fig. 3.2 Steering linkage for independent suspension

Fig depicts one linkage for independent suspension where the above difficulty is avoided. Here three-piece track rod is used the centre portion being called the relay rod, which is connected at one end to an idler arm supported on body structure and to the drop arm of the steering gear at the other end through ball joints the relay rod is restricted to move in horizontal plane only movement is vertical plane is provided by the outer portion viz, the tie rods about the end ball joints.

3.5 Steering gears

The steering gear converts the turning motion of the steering wheel into the to-and-fro motion of the link rod of the steering linkage. More over it also provides the necessary leverage so that the driver is able to steer the vehicle without fatigue.

Type of steering gears

1. Worm and wheel steering gear
2. Can and double roller steering gear
3. Worm and nut steering gear
4. Recirculating ball type steering gear
5. Rack and pinion steering gear.
1. Worm and wheel steering gear

Fig 3.3 Worm and wheel steering gear

Fig shows a simplified diagram of the worm and wheel gear. The movement of this steering wheel turns the worm, which in turn drives the worm wheel. Attached to the wheel spindle rigidly is drop arm, so that a rotation of the steering wheel corresponds to a linear motion of the drop arm end, which is connected to the link rod.

In place of worm wheel only a sector is also sometimes use, but the complete wheel has an advantage over the later in that in this case back lash due to wearing out of the teeth of the worm and worm wheel can be easily adjusted for this purpose the warm wheel is mounted over an eccentric bush. When the teeth have worm out the problem is how to bring the worm and the wheel together to take up the wear. This is done by rotating the bush through a certain angle.

Worm and nut steering gear

The construction of a worm and nut type of steering gear is shown in fig. The steering wheel rotation rotates the worm which in turn moves the nut along its length. This causes the drop arm end to move linearly further moving the link rod and thus steering the wheels.
Recirculating ball type steering gear

This type of gear was perhaps the most widely used steering gear at one time. In India it has been used in the Tata, Dodge, Fargo standard 20 vehicle. It consist of a worm at the rod of steering rod. A nut is mounted on the worm with the two sets of balls in the grooves of the worm, in between the nut and the worm the balls reduced friction during the moment of the nut on the worm. The nut has a number of teeth on the outside, which mesh with the teeth sector, on which is further mounted the drop arm, which stress the rod wheels through the link rod and the steering arms.
When the steering wheel is turned, the ball in the worm roll in the grooves and cause the nut to travel along the length of the worm. The balls which are in to sets are recirculated through the guides as shown in the fig. The movement of the nut cause the wheel sector to turn at an angle and actuate the link rod through the drop arm resulting in the desire steering of the wheels.

The ends play of the worm can be adjusted by means of the adjuster nut provider. The compensate for the wear of the teeth on the nut and the worm, the two have to be brought nearer bodily. To achieve this the teeth on the nut are made tapered in the plane perpendicular to the plane. A screw is also provided by means of which the drop arm, and hence the wheels sector can be positioned alone its axis. When the wheel sector has to be moved bodily closer to the nut to eliminate backlash due to wear, the screws is turned which slides the wheel sector in a direction in which the tapered teeth on the nut are narrower till the required adjustment is achieved.

**Rack and Pinion steering gear**

This type of steering gear is used on light vehicle like cars, and in power steering ex maruti 800 car employ this steering gear it is simple, light and responsive. It occupies very small space and uses lesser number of linkage components compared to the worm and wheel type of gear.

![Rack and Pinion steering gear](image)

Below fig shows the rock and pinion type steering gear along with its linkages the rotary motion of the steering wheel is transmitted to the pinion of the steering gear through universal joints. The pinion is in mesh with a rack. The circular motion of the pinion is transferred into the linear track movement which in further relayed through the ball joints and tie rods to the stub axles for the wheels to be steered.
Types of special steering columns

Special steering column have been employed in many cars which provide safety and ease of operation to the driver.

1. Energy absorbing steering column
2. Tilt wheel steering column
3. Tilt and telescopic steering column
4. Steering column with anti theft lock

3.6 Power steering

Larger amount of the torque is required to be applied by the driver for steering of medium and heavy vehicle. The power steering system provides automatic hydraulic assistance to the turning effort applied to the manual steering system. The power steering system is designed become operative when the effort at the wheel exceeds a predetermined value. Below fig shows a typical power steering system installed on a car.

![Power steering system on a car](image)

3.7 Types of power steering system

1. Integral power steering system
2. Semi integral; power steering system
3. Electronic power steering system
Most power steering systems are operated by fluid under pressure. The fluids usually used are oils of viscosity rating SAE5 or SAE 10W or higher depending upon atmosphere conditions. The systems operate under fairly high pressures which may be as much as 7Mpa.

The principle of working of all the power steering systems is the same. The slight movement of the steering wheel actuates a valve so that the fluid under pressure from the reservoir enters on the appropriate side of a cylinder, thereby applying pressure on one side of a piston to operate the steering linkage which steers the wheel in the appropriate direction.

**Integral power steering system**

The main components of an integral power steering system consist of a hydraulic pump assembly and steering gear assembly connected by means of hoses.

**Fig 3.8 Layout integral power steering system**

A rotary valve power steering gear for the integral system. Using a recirculating ball type worm and wheel steering gear. The steering wheel is connected to the right end of the torsion bar through the steering shaft. The other end of the torsion bar is connected to the worm and also to the spool about which the rotary valve is centered. When the driver applies forces on the steering wheel to steer, the far end of the torsion bar being connected to the spool of the rotary valve and the worm offers resistance. When the force at the wheel exceeds a predetermined value, the spool turns through a small angle.
When the return line is closed and the fluid under pressure goes to one side to the rack piston and moves it to effect steering in the desired direction, The torsion bar is meant to give a feel of the steering to the driver.

The rotation of the steering wheel in the opposite direction connects the other side of the steering gear to the pressure line. In the neutral steer position both sides of the piston (nuts) are shut off the pressure line and so they are at the same pressure but the return line is open due to which the fluid goes on circulating through the valve without causing any steering effect.

Electronic power steering system

In an electronic power steering system connecting two sensors. One torque sensor which converts the steering torque input and its direction into voltage signal. Another rotation sensor which converts the rotation speed and direction into voltage signals is located on the input shaft of the steering gear box.

![Electronic power steering system](image)

**Fig 3.9 Electronic power steering system**

In puts from the steering sensor and the vehicle speed sensor are fed to a micro process control unit where threes are compared with a pre programmed torque assist map. The control unit then sends out the appropriate command signal to the current controller which supplies the appropriate current to the electric motor. The motor pushed the rack to the correct to the right or left depending on in which direction the current flows. Increasing the current to the motor increases the amount of power assist.
Electronic power steering has the following
Advantages over the hydraulic power steering
1. Simple construction
2. No need for the engine to provide mechanical power for steering
3. No problem of leakage of fluid
4. Lesser fuel consumption ., Energy being consumed only while steering
5. Steering assistance available even when the engine is not running
6. While steering manually lesser force is required
The power steering has advantages over the manual steering
1. The steering effort is considerably reduced
2. High degree of steering response
3. In a power – steered vehicle there is less driver fatigue
4. Power steering leads to greater safety.

Summary
• The steering mechanism should be to very accurate and easy to handle
• The steering gear converts the turning motion of the steering wheels into the to-and-fro motion of the link rod of the steering linkage.
• Special steering columns have been employed in many cars which provides safety and ease of operation of the driver.
• The power steering system provides automatic hydraulic assistance to the turning efforts applied to the manual steering system

Short Answer Type Questions
1. Explain the term steering.
2. Write the functions of steering system.
3. What are the requirement for good steering system?
4. Write the types of steering linkages.
5. Explain the term of steering gear.
6. Write the types of steering gears
7. Explin the term power steering.
8. Write the types of power steering systems.
Long Answer Type Questions

1. Explain the steering linkage for vehicle with rigid axle front suspension.

2. Explain the steering linkage for vehicle with independent front suspension.

3. Explain the worn and wheel steering gear.

4. Explain re-circulating ball type steering gear.

5. Explain integral power steering system.

6. Explain electronic steering system.

Practical Questions

1. Inspect the various steering linkages.

2. Inspect the various steering gear.

3. Inspect the power steering gear.

4. Inspect the electronic power steering system.

O.J.T.

1. Dismantling the various steering linkages and indentify the parts.

2. Dismantling the various steering gear and indentify the parts.
4.0 Introduction
4.1 Braking principle
4.2 Types of brakes
4.3 Mechanical brakes
4.4 Self-energizing brakes
4.5 Hydraulic brakes system
4.6 Hand brakes
4.7 Hill holding device

Learning objectives
After studying this unit, a learner will be able to know about

• Parking principle
• Types of brakes
• Working principle of mechanical brakes
• Working principle of self energizing brakes
• Advantage of hydraulic brakes
• Hand brakes
• Hill holding device working principle
4.0 Introduction

The most vital factor in the running and control of the modern vehicle is the braking system. In order to bring the moving motor vehicle to rest or slow down in the shortest possible time, the energy of motion possessed by the vehicle must be converted into some other form energy. The rate of slowing down or retardation is governed by the speed of conversion of energy. Kinetic energy is the energy of motion which is converted into heat given up to air flowing over the braking system.

4.1 Braking principle

Brake are one of the most important control component of vehicle it is required to stop the vehicle with in the smallest possible distance and this is done by converting the kinetic energy of the vehicle into the heat energy which is dissipated into the atmosphere.

4.2 Types of brakes

Brakes are classified according the following considerations.

1. Purpose
   (a) Service brakes
   (b) Parking brakes

2. Location
   (a) Wheel brakes
   (b) Transmission brakes

3. Construction
   (a) Drum brakes
   (b) Disc brakes

4. Method of actuation
   (a) Mechanical brakes
   (b) Hydraulic brakes
   (c) Electric brakes
   (d) Vacuum brakes
(e) Air brake

(f) By – wire brakes

5. Extra braking effort

(a) Servo brakes

(b) Power-operated brakes

4.3 Mechanical brakes

In motor vehicle the wheel is attached to an auxiliary wheel is called a drum. The brake shoes are made to contact this drum the brake shoes have brake linings on their outer surface. Each brake shoe is hinged at one end by an anchor pin, the outer end is operated by some means so that the brake shoe expands outwards- the brake lining come into contact with the drum.

![Diagram of Mechanical Brakes](image)

**Fig 4.1 Mechanical brakes**

Retracting springs keeps the brake shoes in position, when the brake are not applied the drum encloses entire mechanism to keep out dust and moisture.

![Diagram of Toggle Lever](image)

**Fig 4.2 Toggle lever is used to expand shoes**
The wheel attaching bolts on the drums are used to connect the wheel and drum. The braking plate completes the wheel encloser and holds the assembly to the car axle. The shoes are generally mounted to rub against the inner surface of the drum to form an internal expanding brake. When the brake pedal is pressed, the cam turns by means of brake linkage. When the cam turns the shoes expand outwards against the drum. A toggle lever is also used for the same purpose as shown in the above figure. The brake linings rub against the drum and stop its motion.

4.4 Self-energizing brakes

All modern hydraulic wheel brakes of the drum type have a “self-energizing” or “servo” feature, in which the force of the rotating drum is utilized to increase the brake pressure. The “self-energizing” brake shoe action is shown in the above figure. When the vehicle is traveling forward, the drum is rotating in a counter-clockwise direction.

When the brakes are applied, the primary shoe at the left, because of the friction of the rotating drum, tends to move in the direction of the drum’s rotation. The primary shoe is linked to the secondary shoe at the bottom, the secondary shoe is forced around against the anchor pin at the top. The result of this wrapping action is that both shoes are forced into light contact with the drum and the breaking pressure is more uniformly applied.

When the brakes are applied, while the car is in reverse, the secondary shoe tends to move in a clockwise direction against the primary shoe, forcing the later against the anchor pin.
4.5 Hydraulic brake system

The hydraulic brakes are applied by the liquid pressure. The pedal force is transmitted to the brake shoe by means of a confined liquid through a system of force transmission the force applied to the pedal is multiplied and transmitted to all the brake shoes by a force transmission system. This system is based upon Pascal’s principle which states that “the confined liquids transmit pressure without loss and equally in all direction”.

Above fig shows Hydraulic brake system. It essentially consists of two main components

1. Master cylinder
2. Wheel cylinder

The master cylinder is connected by tubing to the wheel cylinders at each of the four wheels. The system is filled with the liquid under light pressure. When the brakes are not in operation, the liquid is known as brake fluid, and is usually a mixture of glycerin and alcohol or castor oil denatured alcohol and some additives.

Each wheel brake consists of a cylinder brake drum which is mounted on the inner side of the wheel and revolves with it, and two brake shoes which are mounted inside the brake drums and do not rotate the shoes are fitted with a heat and wear resisting brake lining on their surface. The brake pedal is connected to the master cylinder piston by means of a piston rod.
When the brakes are to be applied the driver presses the pedal the piston is forced in to the master cylinder, this increasing the pressure of the fluid in the master and in the entire hydraulic system. This pressure is conducted instantaneously to the wheel cylinder on each of the four brakes, where it force the wheel cylinder piston outwards, these pistons in turn force the brake shoes out against the brake drums this brakes are applied.

When the driver release is the brake pedal the master cylinder piston return to its original position due to the return spring pressure, and thus the fluid pressure, and this the fluid pressure in the entire system drops to its original low valve. Which allows retracting springs on wheel brakes to pull the brake shoes out of contact with brake drums into their original position. This cause the wheel cylinder piston also to come back to their original inward position. Thus the brake are released.

**Advantage of Hydraulic Brakes**

1. simple in construction  
2. Equal breaking effort to all four wheel  
3. Increased breaking effort  
4. self compensating system  
5. Low wear rate  
6. Flexibility in breaking lines  
7. High mechanical advantages

**Disadvantages**

1. The braking system fails if there any leakage in the brake lines  
2. The brake shoes are liable to get ruined if the brake fluid leaks out.  
3. This system is suitable only applying brakes intermittently. Fr parking purpose separate mechanical linkage has to be used.

**4.6 Hand brakes**

Hand brake or the parking bakes operate independently of the foot brake. These are used for parking on slopes and during emergency and are also called secondary brakes. Generally these brakes use the same brake shoes as are for the main foot brakes but they have to be actuated by a completely separate mechanism than for the main.
Hand brake is generally located on the side of the driver seat.

On most of the vehicle hand brake applies only the rear brakes. A ratchet release handle to which the catch rod is attached is hinged on the hand brake lever. To the other end of the catch rod, a pawl is attached which slides in the guides fixed on the brake lever. The brake lever itself is hinged on a bracket which is bolted to the chassis frame on the inside. On this bracket is also mounted a ratchet as shown in the figure. The operating cable is attached to the lower end of the brake lever.

To apply the brakes ratchet has to be released first. This is done by pressing the ratchet release handle, which cause the pawl to move up, disengaging the ratchet. Then the brake lever is pulled up which further pull the cable which operates the rear brakes mechanically through a linkage operating on the piston of the rear wheel cylinder, which is in two halves. The ratchet release handle, which had been pressed so far, is released now so that the pawl moves down with the spring action and engages with the ratchet thus keeping the brakes applied.

Another type of hand brake lever operated by pressing button instead of the release handle for releasing the ratchet is shown in the below figure. This is generally used for light duty for which it is currently most popular.
Fig 4.6 Hand brake lever with press button

4.7 Hill Holding device

While going uphill, it is quite difficult to stop a car and then start it again without it slipping down, particularly when the steep in very large. To facilitate such action, special device called hill holding device may be employed.

Fig shows the construction and operation of hill holding device i.e. “No Rol device”. In the figure various valves are shown when the clutch is the engaged position. C is a ball controlling the passage between valves. Band ball C itself Cam D operates the valve B through E. In this position the passage between A and B is open. Thus permitting free passage of brake fluid from the master cylinder to the brakes. This is corresponding to the normal forward driving.

When, however the car is stopped by disengaging the clutch and applying the brake the cam D is operated so that the valve B is pressed against seat A, closing this passage. However the passage between B and C is still open, which keeps the master cylinder in communication with the brake through passage in valve B as shown.

But his happens only while the car in the forward motion while going uphill, however if the clutch is disengaged and the brake applied. The ball C, due to the gravity action, will stop the passage between C and B apart from the passage between B and A, which is closed which is closed by cam D. Thus now if the brakes or released even the fluid under pressure in the brake lines remains there and doe’s not come back through “No Rol” and the brakes remain applied only the car is started the engagement of the clutch would release the brakes automatically by opening the passage between B and Any the means of cam D.
Summary

- Brake are the one of the most important control component of vehicle
- The Hydraulic brake are applied by the liquid pressure
- Hydraulic brake system consist of two main components
  1. Master cylinder
  2. Wheel cylinder
- Hydraulic brake increased breaking effort
- Handle brake are generally located on the side of the driver seat

Short Answer Type Questions

1. Explain the principle of braking system.
2. Write the types of brakes.
3. Write the advantages of hydraulic breaking.
4. Write the disadvantages of hydraulic braking system.
5. What is ABS?
6. Advantages of ABS.

Long Answer Type Questions

1. Write about mechanical brake system.
2. Explain about self-energizing brakes.
3. Write about Hydraulic brake system.
4. Write about hand brake.
5. Write about Hill hold device
6. Give the ABS components description.
7. Explain ABS operation in detail

Practical Question

1. Dismantling all types of brakes and study the each part and assemble it.

O.J.T

1. Know about repairs of all types of brakes
5.0 Introduction

Transmission means the whole of the mechanism that transits the power from the engine crankshaft to the rear wheels. The transmission is also being used very commonly in the literature for a mechanism which provides us with suitable variation of the engine for one at the road wheels.
Whenever required this may be a gear box or an automatic transmission. The main purpose of the transmission is to provide torque ratio between the engine and the road wheels as required.

**Clutches**

Clutch is a mechanism which connects or disconnects the transmission of power from one working part to another, i.e. the crankshaft and the gear box primary shaft.

### 5.1 Characteristic of a Clutch

1. **Transmission of torque**: It should be capable of transmitting maximum torque of the engine.

2. **Gradual engagement**: Without the occurrence of sudden jerks, the clutch should be able to engage gradually and positively.

3. **Dissipation of heat**: Large amounts of heat are generated during operation of clutch. The design of a clutch should be proper to ensure sufficient heat dissipation.

4. **Dynamic balancing**: With the clutch, suitable mechanism should be incorporated for damping of vibration and elimination of noise produced during the transmission.

5. **Size**: In order to occupy minimum amount of space, the size of the clutch should be smallest possible.

6. **Free pedal clutch play**: In order to reduce effective clamping load on the carbon thrust bearing as well as wear on it, provision for clutch free pedal play should be made.

7. **Non-exertive operation of disengagement**: The clutch must have non-tiresome operation of a disengagement for the driver for higher power transmission.

8. The clutch rotating parts should be have minimum inertia.

### 5.2 Types of Clutch

1. Friction clutches

2. Fluid fly wheel clutches

A simplified sketch of a single plate is shown in above fig. Friction plate is held between the fly wheel and the pressure plate. There are springs arranged circumferentially which provide axial force to keep the clutch on engaged position. The friction plate is mounted on a hub which is splined from inside and is thus
free to slide over the gear box shaft. Friction facing is attached to the friction plate on both sides to provides two annular friction surface for the transmission of power. A pedal is provided t pull the pressure plate against the spring force whenever if its required to be disengaged. Ordinarily it remains in engaged position.

When the clutch pedal is pressed the pressure plate is moved to the right against the force of the springs. This is achieved by means of a suitable linkage and a thrust bearing with this movement of the pressure plate, the friction plate is released and the clutch is disengaged.

**Advantage**

1. With the single plate clutch gear changing is easier than with cone clutch because the pedal movement is less in this case.

2. It does not suffer from binding of cones etc.

**Disadvantage**

1. In this clutch springs have to be more stiff and this means greater force required to be applied by the driver while disengaging.

**Multi plate clutch**

The multi plate clutch is an extension of single plate type where the number of frictional and the metal plates is increased. The increase in the number of frictions surface obviously increase capacity of the clutch to transmit torque, the size remaining fixed. Alternatively the overall diameter of the clutch is reduced.
for the same torque transmission as a single plate clutch. This type of clutch is therefore used in some heavy transport vehicle and racing cars where high torque is to be transmitted. This application is finds incase of scooters and motor cycles, where space available is limited.

![Multiplate Clutch Diagram](image)

**Fig 5.2 Multiplate clutch**

A simplified diagram of multi plate clutch is given in above figure. The construction is similar to that of single plate type except that all the friction plates in this case are in two sets i.e. one set of plates slides in grooves on the flywheel and the other one slides on splines on the pressure plate hub.

**Semi – Centrifugal clutch**

For high powered engines the clutch springs pressure required may be considerable and thus the action of disengaging the clutch becomes fatiguing to the driver.

To obviate this trouble the help is taken of the centrifugal force. The clutch springs are designed to transmit the torque at normal speeds. While for higher speeds centrifugal force assists in torque transmission. Such type of clutches are called semi-centrifugal clutches.
Fig 5.3 Semi-centrifugal clutch

Fig shows a semi-centrifugal clutch three hinged and weighted levers are arranged at equal intervals. The lever having fulcrums at A and in hinged to pressure plate at B. The upper end of the lever is weighted at C. D is the adjusting screw, by means of which the maximum centrifugal force and the pressure plate can be adjusted. To reduce friction, the levers are mounted on needle roller bearings on the pressure plate.

At moderate speeds the pressure of the springs is sufficient to transmit the required torque. However at higher speeds the weight C, due to the centrifugal force moves about A as a fulcrum thereby pressing the pressure plate. The centrifugal force is proportional to the square of the speed so that adequate pressure level is attained.

**Centrifugal clutch**

In the fully centrifugal type of clutch the springs are eliminated together and only the centrifugal force is used to apply the required pressure for keeping the clutch in engaged position.

The advantage of the centrifugal clutch is that no separate clutch pedal is required the clutch is operated automatically depending upon the engine speed. This means that car can be stopped in gear without stopping the engine, similarly while starting the driver can first select the gear put the car into the gear and simply press the accelerator pedal. This makes the driving operation very easy.
Fig 5.4 Principle of centrifugal clutch

Fig shows a schematic diagram of centrifugal clutch. As the speed increase the weight A flies, thereby operating the bell crank lever B which press the plate C. This force is transmitted to the plate D by means of springs E. The plate D containing friction lining is thus pressed against to flywheel F thereby engaging the clutch.

Spring G serves to keep the clutch disengaged at low speed say 500 rpm. The stop H limits the amounts of centrifugal force.

5.3 Hydraulic clutches

In heavy duty mechanically operated clutch with high clutch-spring pressure the force required by the driver to release the clutch becomes excessive. This can be remedied by the use of hydraulic operation. Hydraulically operated clutch maybe either single plate type or the more modern multi plate type.

Hydraulic single plate clutch

Fig shows a hydraulically operated clutch when the clutch pedal is pressed the fluid under pressure from the master cylinder reaches the slave cylinder which is mounted on the clutch itself. The fluid under pressure actuates slave cylinder push rod which further operated the clutch release fork to disengage the clutch.

The detailed construction of the clutch master cylinder has been shown in the below fig. In engaged condition when the clutch Pedal is in the released position, the push rod rests against its stop due to the pedal return spring. Also...
the pressure of master cylinder spring keep the plunger in its back position. The flange at the end of the valve shank contact the spring retainer. As the plunger has moved to it rear position the valve shank has the value seal lifted from its seat ans seals spring compresure. Hydraulic fluid can then flow past the three distance. Pieces and valve seal in either direction. This means the pressure in the slave cylinder then is atmospheric and the clutch remains in its engaged position.

Fig 5.5 Hydraulic single clutch

Fig 5.6 Clutch master cylinder
When the clutch pedal is pressed to disengage the clutch, the initial movement of the push rod and plunger permits the seal spring to press the valve shank and seal against its seat. This disconnects the cylinder from the reservoir. Further movement of the plunger displace fluid through the pipe lines to the slave cylinder and disengages the clutch.

Hydraulic operation does not involve frictional wear, especially when subjected to large forces. Due to this reason hydraulic operation is particularly suitable for heavy duty application i.e. on large vehicles.

**Vacuum clutch**

The partial vacuum existing in the engine manifold is put to use for operating the clutch.

![Fig 5.7 Principle of vacuum clutch](image)

A reservoir is connected to the engine manifold through a non-return valve. The reservoir is further connected to a vacuum cylinder through a solenoid-operated valve. The solenoid itself is operated when the driver holds the lever to change gear. Vacuum cylinder contains piston which is exposed to atmospheric pressure on one side the piston is further connected through linkage to the clutch. The movement of Pt piston thus operated the clutch.

In the part of throttle piston there is sufficient vacuum in the engine inlet manifold. When the throttle is opened wide the pressure in the manifold increase but due to this increase of pressure the non-return valve closes, isolating the reservoir from the manifold. Thus a vacuum exist in the reservoir all the time.

In the normal operation the switch in the gear lever remain open and the solenoid operated valve remains in its bottom position. In this position the
atmospheric pressure acts on both sides of the piston in the vacuum cylinder. However when the drover is to change gears, he holds the gear lever.

This action of the driver closes the switch energizing the solenoid which pulls the valve up connecting the vacuum cylinder to the vacuum in the reservoir. Thus the piston is subjected to unequal pressure on two sides which causes it to move. This movement is transmitted by linkage to disengage the clutch. The clutch used in this case is an ordinary friction clutch which remains engaged due to the force of the springs provided in the clutch itself the gear lever switch is opened as soon as the driver releases the lever after changing the gear and the clutch in again engaged.

**Clutch –by-Wire**

In this system there is no mechanical link between the clutch and the pedal. The clutch pedal is electronically controlled by means of an electronic control unit (ECU) and an actuator. A sensor in the pedal measures its exact position which is transmitted to ECU. Information about the car’s behavior from other sensor is also transmitted to ECU, which then operate the clutch through the actuator.

The advantages are improved drive ability better pedal feel and less wear due to absence of mechanical linkage.

![Damper clutch control sleeve](image)

**Fig 5.8 Damper clutch control valve**

The damper clutch control valve applies and releases the damper clutch. Its hydraulic inputs are a constant pressure input from the reducing valve and a vent of pressure through the damper clutch solenoid valve. When the solenoid valve is off, it is closed. The applies high pressure to the control valve, causing it to send a high pressure to the clutch, releasing it. When the solenoid is on, it vents fluid to the sump, lowering pressure at the control valve, and causing it to release pressure at the clutch engaging it.
**Damper clutch control solenoid value**

This solenoid valve is controlled by the ELC control unit. The control unit has five inputs that is used to decide whether the damper clutch should be engaged or not.

- Engine speed is derived from the ignition oil.
- Kick-down speed is derived from a pulse generator.
- Road speed is derived from a pulse generator on a transfer shaft.
- Coolant temperature is derived from an electronic temperature sensor.
- Throttle position is derived from total throttle position sensor or a total throttle position sensor.
- The damper clutch is engaged whenever driving and engine conditions allow good performance under torque converter lockup. Some conditions that might degrade performance will cause the damper clutch to be released.
- To provide better acceleration, the damper clutch is released in first and reverse gears.
- The damper clutch is released when the engine speeds is under 1,300 rpm, again to provide better acceleration.
- The clutch is released for engine speeds under 2,000 rpm with large throttle opening for better acceleration.
- The clutch is released during engine braking to prevent shock.
- The damper clutch will remain released if the engine is not warmed up, coolant temperature.
- Must be higher than specified value for the damper clutch to be engaged.
5.4 Layout of transmission system

The functions of a transmission system.

1. To disconnect the engine from the rod wheels when desired.
2. To connect the engine to the driving wheels without shock.
3. To reduce the engine speed permanently in a fixed ratio.

Summary

- Transmission means the whole of the mechanism that transits the power from the engine crankshaft to the rear wheels.
- Clutch is a mechanism which connects or disconnects the transmission of power from one working part to another.
- Large amount of heat are generated during operation of clutch.
- With the single plate clutch gear changing is easier than with the cone clutch.
- In centrifugal clutch no separate clutch pedal is required the clutch is operated automatically depending upon the engine speed.
- Hydraulic clutch is suitable for large vehicle.
Short Answer Type Questions

1. Define “Clutch”.
2. Write the types of clutches.
3. Write the advantage of single plate clutch.
4. Write the types of hydraulic clutches.
5. Write the function of the transmission system.

Long Answer Type Questions

1. Explain the characteristic of a clutch.
2. Explain the single plate clutch with neat sketch.
3. Explain the multi plate clutch with neat sketch.
4. Explain the semi centrifugal clutch with neat sketch.
5. Explain the centrifugal clutch with neat sketch.
6. Explain the hydraulic single plate clutch with neat sketch.
7. Explain vacuum clutch with neat sketch.
8. Draw the layout of transmission system and give its function.

Practical Questions

1. Dismantling the clutch.
2. Assembly the clutch parts.

O.J.T

1. Identify the problems in clutch operation and rectifying them.
Structure

6.0 Introduction
6.1 Operation in different gear position
6.2 Common troubles or remedies
6.3 Lubrication in gear box

Learning objectives

On completion of this unit a learner will be

- Able to know about necessity of gear box
- Able to know about components in gear box
- Able to know working of gear box
- Able to know about troubles in gear box
- Able to know about remedies for troubles in gear box
- Able to know about lubrication system in gear

6.0 Introduction

The gear box is used as the means of changing the rate of power application by changing the leverage which the engine is having at the driving wheels. The gear box which is fitted between the clutch and the rear axle helps the engine to utilize its power economically under varying load condition.
6.1 Operation in different gear position

This is the simplest type of gear box. The power comes from the engine to the clutch shaft and then to the clutch gear which is always in mesh with a gear on the lay shaft. All the gears on the lay shaft are fixed to it and as such they are all the time rotating when the engine is running and the clutch is engaged. Three direct and one reverse speed are attained on suitable moving the gear on the main shaft by means of selector mechanism. These various position are shown in below fig.
In this types of gear box all the gears are in constant mesh with the corresponding gear on the lay shaft the gear on the main shaft which is splined are free. The doge clutches are provided which are free to slide on the main shaft. The gear on the lay shaft are fixed.

![Fig 6.2 Constant mesh gear box](image)

When the left dog clutch is slid to the left by means of the selector mechanism, it teeth are engaged with those on the clutch gear and we get the direct gear. The same dog clutch however when slid to right makes contact with the second gear and second gear is obtained. Similarly movement of the right dog clutch to the left result in low gear and towards right in reverse gear.

### 6.1.3 Wilson Gear Box

This type of gear box consist of a number of simple epicyclic gear gets compounded together. A Four forward and one reverse speed epicyclic gearing used in Wilson gear box sis shown in below Fig.

A is the input shaft connected directly to the engine crankshaft while R is the output shaft compiled with the propeller shaft through universal joints. C is the multi plate clutch. there are for epicyclic gear trains 1,2,3 and4. Inter connected as shown in fig various gear ratio are obtained as follows.
Direct gear: This is obtained by locking $S_1$, to A by applying the Clutch. In this position we get a “Solid” drive and direct gear is obtained.

**Third gear:** For third gear $S_1$ is held stationary by means of brake $B_1$. In this position arm, $A_1$ is coupled to ring $R_2$ and arm $A_2$ is coupled to ring $R_1$.

**Second gear:** To obtained second gear, brake $B_2$ is applied to keep the ring $R_2$ stationary. The sum gear $S_2$ is already fixed to the engine shaft $A$. Arm $A_2$ is also coupled to the ring $R_1$.

**First gear:** Brake $B_3$ is applied to obtain the low gear.

**Reverse gear:** For reverse gear, the brake $B_4$ is applied which hold the ring $R_4$ stationary.

6.1.4 Planetary Gear

**General**

Planetary gear sets can provide a wide range of gear ratios and combination of gear ratios. One simple planetary gear set produce as many as seven gear ratios, two of these within rotation direction reversal. The simplest planetary gear set includes three members as shown in below figure.
Fig. 6.4 Ravigneaux (Double pinion) type  
- A sun gear at the center of the system

- A planet carrier with at least three planet pinion gears that are free to rotate on their own shafts. The planet pinions rotate around and mesh with the sun gear and the annulus gear.

- An internal annulus gear, sometimes called a ring gear, that rotates around the outside of the planet pinions and meshes with them.

All the automatic transmissions use planetary gears. Most will look much more complex than this simple gear set. An understanding of this example, though, will enable you to understand and analyze more complicated gearing later. The principles we talk about in this section apply equally to the example gear set and to the more complex planetary gears you will find in Hyundai/Kia-transaxle.

**Operation**

All planetary gear sets are operated by holding one number stationary, using another as an input, and using the third as an output. If no member is held stationary, the gears are all able to freewheel and no power is transmitted. If you think about it, you will discover that there are six ways you can operate the gear set you can hold each of the members stationary, use one of the remaining two for input, and use the other for output. The combination, or condition result in variation in direction of travel and gear ratio.

While Hyundai/Kia automatic transaxles may not use all of these gear ratio conditions it is important to understand all six in order to fully understand the power flow through the transaxles you work with.
Direction of Travel

As can be seen from the previous figure (Planetary gear set), the annulus gear, being internally toothed, rotates in the same direction as the planetary gears, and the opposite direction the sun gear. No matter which of the six conditions we operate the gears in the relationship holds. If the planetary carrier is held stationary, input and output rotation will always be in opposite direction. Holding the planet carrier stationary is used to obtain reverse gear. In all other cases, input and output rotate in the same direction.

Gear Ratios

Sun, annulus and planet gears are designed with certain pitch diameters to produce desired gear ratios. The gears ratio we show for the figures in this chapter are just examples. However the basic relationships always the same.

For instance, if we hold the sun gear stationary, use the planet carrier for input and the annulus gear for output, it will always result in torque reduction and speed increase although the amount of each may differ from the example. These constant relationships are shown in below chart.

The following description of conditions all refer to this chart. All six the same set of gears, allowing a comparison of gear ratios for various condition.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
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<td>Gear</td>
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<td>Input</td>
<td>Hold</td>
<td>Hold</td>
<td>Input/output</td>
</tr>
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<td>Output</td>
<td>Out put</td>
<td>Out put</td>
</tr>
<tr>
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</tr>
<tr>
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<td>Increase</td>
<td>Increase</td>
<td>Reduction</td>
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</tr>
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<td>Forward</td>
<td>Forward</td>
<td>Forward</td>
<td>Forward</td>
<td>Back ward</td>
<td>Back ward</td>
</tr>
</tbody>
</table>

Condition # 1 and # 2 : Sun gear held

Condition # 1 and # 2 are both with the sun gear held stationary. Diagrams of condition #1 and #2 are shown in below figures. In condition #1, the planet carrier is the input and the annulus gear is the output. The input-to-output ratio is 0.7:1, providing an increase in speed and a reduction in torque. Any ratio such as this one, where the first number is smaller than 1.0 provides an increase in rotational speed and a decrease in torque.

On the other hand, a ratio where the first number is larger than 1.0 indicates an increase in torque and a reduction speed.
With the input and output exchanged as in below figure, the annulus gear and input as the planet carrier as the output, the result is exactly the opposite, as you might expect. There is an increase in torque and a reduction in speed. The input-to-output gear ratio is the reciprocal of the ratio on condition #1, 1.45:1.

Condition #3 and #4: Annulus gear held

In condition #3 and #4, the annulus gear is held stationary. Diagram of condition #3 and #4 are shown in below figures. In condition #3, the sun gear is the input and the planet carrier is the output. The input-to-output ratio is 3.23:1 the highest torque output of any the six condition, and so the greatest speed reduction.
Condition #5 and #6 Planet carrier held

In condition #5 and #6, the planet carrier is held stationary. Condition #5 and #6 are shown in below figures. Since the two rotating members are the annulus gear and the sun gear, the output direction of rotation is the reverse of
the input for both condition. With the annulus gear as the input and the sun gear as the output as in below figure, the input-to-output ratio is 0.45:1 producing an increase in speed and a reduction in torque.

With condition #5 input and output reversed as in below figure the sun gear is the input and the annulus gear is the output. The input-to-output is 2.10:1, making this a low speed, high torque condition, well suited for a reverse gear range in a transaxle. There are seven gear ratio to be derived from a simple planetary gear set. The seventh gear ratio is direct drive, and results when any two of the three members of a gear set are locked together. When two members are rotating at the same speed in the same direction, the effect is the same as lockup. In this condition, the input-to-output ratio is 1.0:1 a direct drive condition. Input and output speed are equal as are input and output torque.
6.2 Common troubles and remedies

Trouble: 1. Noisy operation of the gear box cases

Cases: 1. Noisy running in stationary
2. Running In various gears.

1. Stationary running

(a) The bearings may be worn out
Remedies: Replaced the bearing
(b) Counter shaft may be bent or worn
Remedies: Replace the counter shaft
(c) Constant mesh gear may be worn out
Remedies: Replace the gear

2. When vehicle is moving

(a) Gear may be worn out
Remedies: Replaced the gears
(b) Gear may be loose on the main shaft due to worn out splines or the gears on the main shaft.
Remedies: Worn out parts should be replaced
(c) The bearing may be worn out
Remedies: Replace the worn out bearings

3. Hard gear shifting

Cause A: Clutch adjustment may not correct
Remedies: Which should be corrected
Cause B: Clutch linkage may be binding
Remedies: The same may be repaired to lubricated as required.
Cause C: The gear shaft mechanism may not be adjusted or lubricated properly
Remedies: Which must be done immediately
Cause D: Gear lever ball joint may be binding
Remedie: Which should be lubricated

4. Gears Clash while shifting

Cause A: Adjustment of clutch may be incorrect
Remedie: Which may be checked and corrected if necessary

Cause B: Clutch linkage may be binding
Remedie: Which may be repaired or lubricated as required.

Cause C: Misalignment of the clutch housing
Remedie: Which may be check at the rear face and corrected if required.

5. Gear Locked in One Gear

Cause A: Selector fork may be bent or selector rod may be worn or broken
Remedie: To correct inspect the various components of the gear shift mechanism and replace the defective parts

Cause B: Teeth on any gear may be broken
Remedie: After inspection the defective gear has to be replaced

Cause C: Any other part of the gear train may be worn or broken
Remedie: Gear box has to be disassembled and defective parts replaced.

6. Gear slipping

Cause A P: The selector mechanism may be worn out or the springs may be weak
Remedie: The replacement is the only remedy in this case

Cause B: The gear teeth or the dog clutch member may be worn out.
Remedie: Which should be replaced

Cause C: The main shaft splines may be worn out or damaged
Remedie: The main shaft has to be replaced

7. Leakage of the gear box oil

Cause A: Damaged oil seals
Remedie: Which should be replaced

**Cause B:** The bolts on the gear box cover may be loose

Remedie: Which should be tightened properly

**Cause C:** The breather hole at the top of the gear box may be blocked

Remedie: Which may be opened up

**Cause D:** The drain plug may be loose or damaged

Remedie: Which may be tightened or replaced as required.

### 6.3 Lubrication in gear box

Lubrication of gear box is done by putting oil of specifications given by the manufacture in the gear box to ensure that at least one gear dips in the oil with the clutch engaged the gears will rotate and splash the oil. The gear oil is thicker than the engine oil.

Through the lubrication oil for the gear box is not subjected to the severe conditions of high temperatures and consequent carbonization as in case of engine oil, yet it present to problem of oil sealing, it being at much higher pressures. If the oil leaks past the gear box input shaft to the clutch. The friction lining there will be wetted and the clutch will stop functioning properly. For this purpose, firstly, proper oil seals must be fitted to the gear box shaft bearings, secondly the oil used must not be thinner than the one specified by the manufactures, and thirdly a breather hole.

Is provided at the top of the gear box case to relieve any access pressure. A thicker oil. If used, will be a source of wastage, because much effort will be wasted in charming the oil. The same thing will happen in case the oil is fitted above the prescribed level. Apart from the increased possibility of leakage.

The oil used for gear box lubrication is generally S.A.E 80 or 90. There is not much consumption of oil as such, but leakage may occur. Therefore the oil level is the gear box must be checked periodically. After some time, when the oil because contaminated (about 20,000-25,000 km) the entire oil in the gear box should be drained and replaced with fresh oil.
Summary
- The gear box is fitted between the clutch and the rear axle.
- In constant mesh gear box all the gears are in constant mesh with the corresponding gears on the lay shaft.
- In Wilson gear box number of simple epicycle gear stets compounded together.
- The oil used for gear box lubrication is generally S.A.E 80 or 90.

Short Answer Type Questions
1. What is the functions of gear box?
2. Write the types of gear boxes.
3. Write the names of the components in the gears box.
4. What grade of the oil is used for lubricating in gear box?
5. When the lubricating oil in gear box should be changed.

Long Answer Type Questions
1. Explain the sliding mesh type of gear box with neat sketch.
2. Explain the constant mesh gear box with sketch.
3. Explain the Wilson gear box with neat sketch.
4. Give the common troubles and their remedies in gear box.
5. Write about lubrication in gear box.

Practical Questions
1. Over hauling the gear box.

O.J.T
1. Open the gear box and find out the troubles and repairing it.
UNIT 7

Engine Cooling System

Structure

7.0 Introduction
7.1 Engine cooling Methods
7.2 Air cooling system
7.3 Water cooling system
7.4 Parts of water cooking system
7.5 Reason for Engine over heating

Learning objectives

On completion of this unit a learner will be

• Able to know about necessity of air and water cooling in A.C Engine
• Able to know about types of cooling system
• Able to know about water cooling system
• Able to know about types of water cooling methods
• Able to know about pars of water cooling system
• Able to know about Reason for Engine over heating
Introduction

The temperature of the burning gases in an automobile engine is about 1500°C to 2000°C and that of the exhaust gases is 600°C to 800°C. This temperature range is quite high in comparison to the melting temperature of the highest melting point metals. If the extra heat contents in the engine are not removed the lubricating oil on the cylinder walls would be burnt away resulting in the seizing up of the piston.

This will also result in the burning and warping of the valves, breaking down of the lubricating oil and overheating of the piston, valves and bearing. It is therefore necessary to withdraw the extra heat from the cylinder piston valves etc to keep their temperature within safe limits. For this purpose, these parts are called by some form of cooling system.

Engine cooling Methods

1. Air cooling system

2. Water cooling system

   (a) Thermosyphon system

   (b) Pump circulation system

Air cooling

The principle of the method is to have current of air flowing continuously over the heated metal surface from where the heat is to be removed. The heat dissipated depends upon following factor:

   (a) Surface area of metal into contact with air

   (b) Mass flow rate of air

   (c) Temperature difference between the heated surface and air

   (d) Conductivity of metal

For an effective cooling the surface area of the metal which is in contact with the air should be increased. This is done by using fins over the cylinder barrels. These fins are either cast as an integral part of the cylinder or separate finned barrels. To increase the contact area still further, baffles are used sometimes.
Advantages of air cooling system

1. Air cooled engines are lighter because of the absence of the radiator, the cooling jackets and the coolant.
2. They can be operated in extreme climates where the water may freeze.
3. In certain areas where there is a scarcity of cooling water, the air cooled engine is an advantage.
4. Maintenance is easier because the problem of leakage is not there.
5. Air cooled engines get warmed up earlier than the water cooled engines.
Disadvantage

1. It is not easy to maintain even cooling all around the cylinder so that the distortion of the cylinder takes place. This defect has been remedied sometimes by using fins parallel to the cylinder axis.

2. As the coefficient of heat transfer for air is less than that for water there is less efficient cooling in this case and as a result the highest useful compression ratio is lesser in the case of cooled engines than in the water cooled once.

3. The fan used is very bulky and absorbs a considerable portion of the engine power to drive it.

4. Air cooled engines are more noisy.

7.3 Water Cooling system

In water cooling system, the cooling medium used is water. In this the engine cylinder are surrounded by water jackets through which the cooling water flows. Heat flows from the cylinder walls into water which goes to the radiator where it loses its heat to the air.

There are the two types

1. Thermosyphon system
2. Pump circulation system

7.3.1 (1) Thermosyphon system

It consist of a radiator connected to the engine through flexible hoses. In this system circulation of water is obtained from the difference in densities of the hot and the cold regions of cooling water. The circulating water gets heat from the engine cylinder thereby cooling the same.

The same heat in the water is then dissipated in to the atmosphere, through the radiator by mainly conduction and convention therefore the circulating water becomes cold by the time it reaches. The collector tank of the radiator.

The same water in then circulated through the engine to collect heat from the cylinder. The rate at which water circulated in this system is proportional to the heat output or the load on engine and not to the engine speed.

Some of the thermosyphon systems also had fans mounted behind the radiator and driven by belt and pulleys from the crankshaft to assist the flow of cooling air.
Advantages

1. Construction is simple
2. Low initial cost

Disadvantages

1. Cooling is slow
2. Capacity of the system has to be large
3. The engine takes more time to reach the operating temperature
4. Certain minimum level of coolant must be maintained.

7.3.2 Pump circulation system

This system is similar to thermosyphon system described above with the only differences that a pump is used for the circulation of coolant and a thermostat is employed to control the flow of coolant.

The pump is driven by means of belt from the engine crankshaft. The drive for the fan is also obtained from the same belt that drives the pump and the generator.
Advantages

1. Circulation of coolant is proportional to both load and speed.
2. Circulation of coolant is positive and hence more efficient due to which the smaller water jackets can be used resulting in overall decrease of engine size.
3. There is no necessary to place the radiator header tank at above the engine level.
4. Radiator need not be placed in the front it can be placed on the side or in the rear.

7.4 Parts of water cooking system

The main components in this system are
1. Radiator
2. Thermostat
3. Fan
4. Pump

7.4.1 Radiator

The radiator is a device for having a large amount of cooling surface to the large amount of air so that the water circulating through it is cooled efficiently.
It consists of an upper tank and a lower tank and between them a core. The upper tank is connected in the water outlets or outlets from the engine jackets inlet through the pump. The core is a radiating element which cools the water. There are two basic types of radiator cores: one is tubular types and another is cellular types.

In tubular type core, the upper and lower tanks are connected by a series of tubes through which water passes. Fins are placed around the tubes to improve heat transfer. Air passes around the outside of the tubes, between the fins absorbing heat from the water it is passing. In cellular type core, air passes through the tubes and the water flows in the spaces between them. The core is composed of a large number of individual air cells which are surrounded by water. Because of its appearance, the cellular type is usually known as a honeycomb radiator, especially when the cells in front are hexagonal in form.

In tubular radiator, because the water passes through all the tubes, if one tube becomes clogged, the cooling of any passage results in a loss but of small part of the total cooling surface. Radiator is also classified according to the direction of the water flow through them. In some the water flows from top to bottom down flow type radiator.

In other, the water flows horizontally from an input tank on one side to another tank on the other side—cross flow type radiator. Radiator are usually made of copper and brass because of their high heat conductivity. The various section the radiator are most completely joined together by soldering.
7.4.2 Thermostat

To keep a rigid control over the cooling a thermostat is used which automatically keeps the cooling water temperature at a predetermined value. Two types of the thermostat are used in automobiles.

1. Bellows or aneroid type
2. Wax or hydrostatic type

7.4.2.1 Bellows types thermostat

It consists of metallic bellows particularly filled with some volatile liquid like acetone, alcohol, or either which boils between 7-85°C. A valve attached to one end of the bellows while to the other end is attached a frame which fits into the cooling passage. The thermostat is fitted in the coolant hose pipe at the engine outlet when the engine after start is warming up it, is desired that the cooling system should not operate so that the engine warms up early.

During this period the thermostat valve remains closed because the liquid inside as yet has not changed its state. As the coolant temperature reaches a predetermined value about 80°C the liquid inside the thermostat is converted into vapour which exerts a pressure on the value, which begins to open so that the water circulation through the radiator starts.

The valve then opens gradually for there as the water temperature rises, until it is fully open at about 90-95°C. Thus the thermostat controls the flow of water through the radiator according to the engine cooling requirements.
7.4.2.2 Wax Thermostat

A wax element thermostat is shown in below fig. As the coolant is heated, it transfers its heat to the copper-loaded wax having a high coefficient of volumetric thermal expansion which expands so that the rubber plug contracts against the plunger and exerts a force on it upwards so that it moves vertically. This movement of the plunger opens a valve in the thermostat to allow coolant to flow through the radiator.

This type of thermostat, in contrast to the bellows type, is not sensitive to pressure variations. Thus, it is more reliable to operate within the specified temperature range.
7.4.2.3 Pump

A pump is used in water cooling systems to increase the velocity of the circulating water. Impeller type pumps are mounted at the front end of the cylinder block between the block and radiator. The pump consists of a housing with an inlet and outlet and an impeller. The impeller is a flat plate mounted on the pump shaft with a series of flat or curved blades or vanes. When the impeller rotates, the water between the blades is thrown outwards by centrifugal force, and is forced through the pump outlet and into the bottom of the radiator. The water from the radiator is drawn into the pump to replace the water forced through the outlet.

The pump is driven by a belt to the driver pulleys mounted on the front end of the engine crankshaft. The impeller shaft is supported on none or more bearings. A seal prevents water from leaking out around the bearings. The packless type pump is used in modern engines. The packing gland type pump is found only in older models.

7.4.2.4 Fan

When the engine is cool or even at normal operating temperature, the fan clutch partially disengages the engine’s mechanically driven radiator cooling fan, generally located at the front of the water pump and driven by a belt and pulley connected to the engine’s crankshaft. If engine temperature rises above the clutch engagement temperature setting, the fan becomes fully engaged, thus drawing a higher volume of ambient air through the vehicle’s radiator which in turn serves to maintain or lower.
The engine coolant temperature to an acceptable level. Mechanical fans are most common in trucks and some cars. This is easier to accomplish because the engine is mounted longitudinally with the belt accessory components mounted facing the radiator. The fan will spin in between the radiator and the engine to help with cooling.

Fig 7.8 Water pump and cooling fan

7.5 Reason for Engine over heating

1. Accumulation of rust or scale in the coolant jackets and the radiator.
   
   Remedy: Use suitable chemical and reverse flushing

2. Defective hose of faulty connections
   
   Remedy: Replace the defective hose and tighten the various connections

3. Sometimes the engine block may also be cracked causing loss of coolant
   
   Remedy: Engine block may be suitably repaired

4. Defective coolant pump reduces the volume of the coolant circulated
   
   Remedy: Open it and look for the defects which may be corrected

5. A defective thermostat that may be sticking in the closed position will not allow the coolant to go to the radiator and be closed there
   
   Remedy: Replace it

6. Fan belt may be slipping
Remedy: Replace it

7. The air passage in the radiator may be blocked.
Remedy: Clean it

8. Loss of coolant by evaporation
Remedy: Filling the radiator to the correct level

9. Radiator fan thermostat, switch may be defective
Remedy: Switch should be replaced

Summary

- Too much removal of heat decreases the thermostat efficiency of the engine
- The amount of heat dissipated depends on the surface area of metal, rate of air flow conductivity of material
- Air cooling is cheaper and faster
- Air cooled engines more noise
- Water cooling is two types
  1. Thermosiphon and
  2. Pump circulation type
- Radiator is the main component of cooling system
- The water pump is used for heavy duty engines
- The fan is rotated by crankshaft.

Short Answer Type Questions

1. Explain the necessity of cooling system in I.C Engines.
2. Explain the disadvantages of air cooling system.
3. Write the types of cooling methods.
4. What are the factor effect the heat dissipated in air cooling method?
5. Write the disadvantages of water cooling system.
6. Write the components of water cooling system.
**Long Answer Type Questions**

1. Explain the air cooling system with neat sketch.
2. Write the advantages and disadvantages of air cooling system.
3. Explain the thermostyphon system with neat sketch.
4. Explain the pump circulation system with neat sketch.
5. Explain the Radiator with neat sketch.
6. Explain the working of Bellows or aneroid types thermostat with sketch.
8. Write the reason for Engine overheating.

**Practical Questions**

1. Study the air cooling system of two wheelers.
2. Study the parts in water cooling system.
3. Dismantling the water cooling system parts and cleans the radiator.
4. Over hauling the pump.

**O.J.T**

1. Find out the problems in cooling systems and rectifying them.
Structura

8.0  Introduction
8.1  Types of lubricants
8.2  Objects of lubrications requirement
8.3  Properties of lubricants
8.4  Types of lubrication system
8.5  Filters

Learning Objectives

After studying this unit student will be able to.

- Able to know types of lubricants
- Able to know about objects of lubrication
- Able to known about properties of lubricants
- Able to know about Need of lubrication
- Able to know about different lubrication
- Able to know about Oil Filters
8.0 Introduction

Lubrication is very important for reciprocating parts of an engine. Lubrication helps to provide cushioning to the reciprocating parts as well as it cleans the parts from dust lubrication helps to prevent the parts from corrosion and wear and tear.

8.1 Types of Lubricants

1. Motor Oil: Naphthalene bake oils
2. Lubricants: Gear oil, semi solid like grease
3. Cylinder oil: Unfinished oil
4. Neutral oil: Motor oils and light machine oil

8.2 Objects of Lubrications or requirement

Lubricants for Automobiles

1. To minimize the friction and wear
2. To cool by carrying away heat
3. To seal the piston’s and thus preventing escape of gases in the cylinder with consequent loss of power
4. To cushion the parts against vibration and impact
5. To clean the parts as it lubricants them, carrying away impurities
6. Lubrication is mainly required for main crankshaft bearings
7. To lubricates the big end bearings
8. Lubrication for the small end bearings
9. Crankshaft bearings, piston rings and cylinder wall, timings gears, valve mechanism are lubricated.

8.3 Properties of lubricants

1. Viscosity: The viscosity of the lubricating oil should be just sufficient to ensure hydrodynamic lubrication
2. Flash point: The flash point of the oil should be sufficiently high
3. Power Point: The power point of the oil should be less than the lowest temperature encountered in the engine.
4. **Physical stability**: The lubricating oil must be stable physically at the lowest and the highest temperatures encountered in practice.

5. **Chemical stability**: At higher temperatures the oil should remain chemically stable.

6. **Resistance against corrosion**: The oil should not have any tendency to corrode the parts.

7. **Clean lines**: The oil should be sufficiently clean and stable itself.

8. Resistance Against Extreme Pressures

The lubricating oils should be have sufficient resistance against this tendency

### 8.4 Types of Lubrication System

1. Petrol system
2. Splash system
3. Pressure system
4. Dry-sump system

**Petrol system**

This system of lubrication is generally adopted in two stroke petrol engines like scooters, mopeds, and motorcycles. It is the simplest of lubricating system. It does not consist of any separate part like oil pump for the purpose of lubrication. The lubricating oil is mixed into the petrol itself while filling in the petrol tank of the vehicle, in a specified ratio. When the fuel goes into the crank chamber doing the engine operation, the oil particles go deep into the bearing surface and lubricated them. The piston rings, cylinder walls, piston pin etc are lubricated in the same way.

**Problem**: Clogging of passages in the carburetor resulting in the engine starting trouble.

**Splash Lubrication System**: In this system of lubrication the lubricating oil is stored an oil sump. A scoop or dipper is made in the lowest part of connecting rod. When the engine runs, the dipper dips in the oil once in every revolution of the crankshaft and causes the oil to splash into the cylinder walls. This action effects the lubrication of the engine walls, piston rings, crankshaft bearings and big end bearing, splash system. Mostly works in connection with the pressure system in an engine, some parts being lubricated by splash system and other by pressure system.
**Pressure system**: In this system of lubrication the engine parts are lubricated under pressure feed. The lubricating oil is stored in a separate tank on the sump from where an oil pump takes the oil through a strainer and delivers it through a filter to the main oil gallery at a pressure of 2-4 kg/cm$^2$. The oil from the main gallery goes to the main bearing falls back to the sump, some is splashed to lubricate the cylinder wall and the remaining goes through a hole to the crankpin. From the crankpin it goes into the piston pin through a hole in the connecting rod web, where it lubricates the piston rings.

![Diagram of lubrication system](image)

**Fig 8.1 Forced of lubrication**

**Splash lubrication**

For lubricating crankshaft and timing gears, the oil is led through a spate oil line from the oil gallery. The valve tappets are lubricated by connecting the main oil gallery to the tappet guide surface through drilled holes. An oil pressure gauge at the instrument panel indicates the oil pressure in the system clear off the oil from dust metal particles and other harmful particles.

**Parts of lubricating system**

- Oil sump or tank
- Oil pump
- Oil cooler
- Oil filter and strainer
- Oil pressure gauge
- Oil level indicator
- O.P Indicating light
8.5 Filters

The main function of the oil filters is to filter out the dirt or grit particles from the oil. The oil filters clears the dust particles settled in the oil through the burning of the fuel. Thus the oil filters are helpful to clean the various parts of engine from dust and dirt.

Types of filters

Different types of filtering elements are used in automotive engines.

1. Cartridge type
2. Edge type
3. Centrifugal type

1. Cartridge type filter

This type filter consist of a filtering element place in the metallic casing. The impure lubricating oil is made to pass through the filter elements, which takes up all the impurities. The element is given a pleated form to maximize the surface area of the filters for a given size of element. The oil enters the filter at the top and passes through the filter elements as shown by arrows in the fig. The pure oil then goes to the porous, metallic tube from where it goes to the outlet for circulation. A drain plug is also provided. Commonly used material for filter in are wire gauge, cotton, felt, paper, plastic impregnated paper etc.
It is also called the stack type. In this the oil is made to pass through a number of closely spaced discs. The alternate disc are mounted over central spindle while the disc in between these are attached to a separate fixed spindle the clearance between two successive disc is a few microns. The oil is made to flow through the spaces between these discs and because of the very small spaces involved the impurities are left on the disc peripheries from where these are periodically removed by simply operating the central knob. This may be done either manually or the knob may be connected to the clutch system and operated periodically by means of clutch action.
This types filters consist of a stationary casing, rotor casing, central spindle and tubes with jets. The impure oil enters the hollow central spindle through the holes around its periphery. The oil goes to the rotor casing. From the rotor casing the oil goes in the tubes, at the ends of which jets under pressure, the reaction of which gives the motion to the rotor casing. So that it starts rotating the oil from the jets impinges on the walls of the stationary casing under heavy pressure, where the impurities are retained and the clean oil falls below which is taken for use. The filter walls are cleaned periodically.

**Summary**

- Lubrication used for smooth running of the automobile
- Lubrication provides the engine reciprocating parts neat and clean.
- Lubrication decrease the noises of the engine
- Lubrication is used for minimizing the friction and wear
- The oil filters out the dust and dirt entering the engine

**Short Answer Types Questions**

1. What are the types of lubricants used in automobiles?
2. Mention any two important properties of lubricating oils.
3. Mention the requirement of lubricating system.
4. Write the types of lubrication systems.
5. Write the parts of lubricating system.
6. What are the uses of the filters?
7. Write the types of the filters.

**Long Answer Type Questions**

1. Explain the properties of lubricants.
2. Explain the splash lubricating system with neat sketch.
3. Explain the pressure lubricating system with neat sketch.
4. With neat sketch explain the cartridge type filter.
5. With neat sketch explain the centrifugal types filter.
6. With neat sketch explain the edge oil filter.
Practical Questions

1. Lubrication oil flow system in engine.
2. Construction of oil filters.
3. Working of oil filters.

O.J.T

1. Overheating the oil filters.
2. Study the trouble shooting in lubrication system.

Note

SAE number: The Society of Automobile Engineers (SAE) rates oil viscosity in two different ways for winter and for other than winter. Winter grade are 3 grades, SAEW SAE 10W, and SAE 20W, indicates winter grade. Other than winter grades are SAE 20, SAE 30, SAE 40, and SAE 50.
9.0 Introduction

In the carburetor breaking up and mixing of air with fuel in correct proportions to meet engine requirement to be done. The air fuel mixture so obtained from the carburetor is called the combustible mixture.

The carburetor supplies rich mixture for starting accelerating and high speed operations. Lean mixture for intermediate speed with a warm engine. The theoretically perfect mixture of air and gasoline contains 15 parts of air and 1 parts of gasoline by weight.
9.1 Types of carburetor

There are three types

1. Up-drought type
2. Horizontal type
3. Down - Drought type

Down drought type is the one most commonly used

Carter Carburetor

It is a down drought type carburetor

It consist of the following circuits

1. Float circuit
2. Starting circuit
3. Idle and low speed circuit
4. Port throttle circuit
5. Full throttle circuit
6. Acceleration pump circuit.

Fig 9.1 Carter Carburetor
The float circuit control the supply of the fuel from the fuel filter into the float chambers. The float is pivoted at a side of the chamber and operates a needle valve to close and open the passage through which the fuel enters the chambers.

At the time of starting the cold engine the choke valve is operated to close the air supply. The chock vale is mounted eccentrically due to which it opens automatically after the engine has started the whole section is applied on the min nozzle which delivers fuel. The air supply being quite small the air fuel mixture becomes rich for starting. A rich mixture becomes rich for starting. A rich mixture is required in small quantity for idling.

The throttle valve is almost closed during the idling. Thus the engine suction is applied at the idle port which supplied the required air fuel mixture. For low speed the throttle valve is little opened the main nozzle also begins to supply the fuel. The throttle valve is further opened for increasing the speed. At this stage the throttle valve is partly opened and the fuel is supplied by the main nozzle only.

When the throttle valve is fully opened the maximum amount of air passes through the venture and a higher rate of fuel supply is required. This is achieved by means of the metering rod. When the acceleration pedal is depressed the throttle valve is fully opened and simultaneously the metering rod is lifted up in the jet providing larger area for fuel supply. This amount of air fuel mixture is supplied for high speed.

**Zenith Carburetor**

![Diagram of Zenith Carburetor](image-url)
The zenith carburetor is one of the most popular carburetor. The current model of zenith carburetor contains economy device and accelerating pump. The old type of float chamber the fuel centers from the bottom and the flat is controlled by toggle lever. This systems entirely eliminated in recent year. There are 3 jets main jet, compensating jet and idling jet in the carburetor.

This compensating jet is around the main jet the choke valve is used for starting. For idling and slow speed running the air enters through the holes A and B mixes with the fuel in idling passage and the mixture passes to the idling jet. A separate knob is provided for idle adjustment which controls the operating B to supply the mixture. When the throttle valve is opened the main jet comes into action along with the idling jet. On further opening the throttle valve the whole suction is applied on the main and compensating jet, the idling jet is cut off the compensating jet tracks care to maintain correct air fuel ratio at different speeds.

S.U Carburetor

The S.U carburetor is an example of constant vaccum type of carburetor. It consist of a single jet in which a tapered needle operates. The area of the throat is varied by means of a piston which slides up and down. The tapered needle is connected to the accelerator.
When the accelerator is operated the piston move up and down in the throat, controlling the supply of air. And the needle moves up and down to the jet, controlling the supply of fuel. When the piston moves down, throat area decreases the annular area in the jet to pass less fuel. The piston and tapered needle are so designed that they maintain correct air fuel mixture at different operating conditions of the engine.

The upper side of the piston is connected to the throttle passage through a slot cut in the piston. The lower side is covered to the atmospheric pressure. Thus the piston at any instant depends upon the balance of its own weight against the vacuum force. As the weight of the piston is constant, the vacuum also remains constant. The jet can move broadly up and down with respect to the tapered needle by an adjusting screw fitted at the bottom of the screw. This is done for adjusting the mixture strength; there is no separate idling or slow speed system and no accelerating pump. This type of carburetor is the rapid response during accelerating and hence, it is fitted with racing cars and is most of the scooters and motorcycles.

9.2 Different adjustment and their purposes

1. Idle adjustment

There is a idle adjustment screw provided in the carburetor screwing, in the same decrease the idle part area and hence dresses the engine speed. The screw is adjusted till the engine runs smoothly at required speed.

2. Throttle adjustment

On releasing the accelerator pedal throttle valve should be completely closed while on pressing pedal fully, it should be in full open position. This may be checked and if not found correct. The linkage may be adjusted as provided for in the manufacturers manual.

3. Other adjustment

A part from the idle and throttle adjustment the other adjustment which are provided is some carburetors are for accelerating pump, metering rod, floats etc they may be performed as laid down is the manual.

Summary

- The supply of rich or lean air fuel mixture is done by the carburetor
- Idle air fuel mixture gives the engine to run idle when the vehicle stops for a less time
- Down drought type carburetor is the one most commonly used.
• The float circuit controls the supply of the fuel from the fuel filter into the float chamber.

• The SU carburetor is an example of constant vacuum type of carburetor.

**Short Answer Type Questions**

1. Explain the term “Carburetor”.

2. Write the types of carburetor.

3. What are the circuits presence in the carter carburetor?

4. Explain the throttle adjustment.

**Long Answer Type Questions**

1. Explain the working of a carter carburetor with neat sketch.

2. Explain the zenith carburetor with neat sketch.

3. Explain the SU carburetor with neat sketch.

4. Explain different adjustment and their purposes in carburetor.

**Practical Questions**

1. Construction of types of carburetors.

2. Different adjustment in carburetor.

**OJT**

1. Studying source of carburetor trouble and remedies.
UNIT 10

Fuel Injection System

Structure

10.0 Introduction
10.1 Fuel feed system in vehicles and its layouts
10.2 Study of diesel fuel supply
10.3 FIP timing
10.4 Engine idling speed adjustment
10.5 Study of LPG as fuel for vehicles
10.6 Study of CNG driving vehicle
10.7 Study of Air conditioning

Learning Objectives

After studying this unit student will be able to

- Able to know about fuel feed system in vehicles
- Able to know about fuel feed system layouts
- Able to know about Diesel fuel supply
- Able to know about FIP timing
- Able to know about Engine Idling Speed adjustment
- Able to know about LPG driving vehicle
10.0 Introduction

In petrol engine the fuel supply system consist of fuel tank, fuel lines, fuel pump, fuel filter, air cleaner, carburetor, inlet manifold and return pipelines. In diesel engine fuel tank, filter fuel injection pump fuel injection.

10.1 Fuel feed system in vehicles and its layouts

![Diagram of petrol engine fuel system](image)

**Constructional details of fuel feed system**

1. Fuel tank
2. Fuel pump
3. Fuel filter
4. Carburetor
5. Intake manifold
6. Fuel lines

**Fuel Tank:** The fuel tank is made of sheet metal. It is usually attached to the frame of a rear of vehicle. It is capacity ranges from 70 to 120 liters. The filler neck of the tank is closed by a cap. A drain plug is provided at the bottom for emptying the tank. The tank also contains the float unit of the fuel gauge.

It may also have a vent pipe which allows air to escape when the tank is being filled. In the cars, that are equipped with vapor recovering system. The vent pipe is connected to condenser which contains the vaporized gasoline in the tank and prevent its escape into the air.
**Fuel Pump:** A fuel pump is used to deliver fuel from the fuel tank to the float chamber of carburetor. Main types of fuel pumps commonly used on auto vehicle are

1. A.C Mechanical pump
2. S.U Electrical pump
3. Electrical pump
4. Fuel pump with a vaccum pump

**Fuel filter**

The fuel is filtered at different stages in a fuel supply system. The fuel filter serves the purpose of filtration in the fuel delivery system by preventing foreign particles from entering into the fuel pup and the carburetor. The modern filtration practice employs a combination of coarse and fine filters. Coarse filters are incorporated with the fuel tank. Fine filter are placed between the fuel pump and the carburetor.

**Carburetor:** The carburetor is a device for atomizing and vaporizing the fuel and mixing it with the air in varying proportions to suit the changing condition of spark ignition engines. The air fuel mixture so obtained from the carburetor is called the combustible mixture. The mixture must be rich for starting accelerating and high speed operation. The mixture should be lean for operation at intermediate speed with a warm engine. The theoretically perfect mixture of air and gasoline contains 15 parts of air and 1 parts of gasoline by weight.

**Fuel Lines**

The copper or steel tubes and hoses are used for connecting fuel tank with pump with carburetor. The tube connecting the fuel tank and pump is fastened rigidly to the frame or body. The first last portion generally consist of a flexible tube that joints the rigid line to the fuel tank or to the pump. This allows the fuel tank to oscillate with the body and the pump with the engine without breaking or loosening the line.

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**10.2 Study of diesel fuel supply**

**Tank**

The fuel tank is made of sheet metal. It is usually attached to the frame of a rear of vehicle. It is capacity ranges from 70 to 120 liters. The filler neck of the tank is closed by a cap. A drain plug is provided at the bottom for emptying the tank. The tank also contains the float unit of the fuel gauge. It may also have a vent pipe which allows air to escape when the tank is being filled.
Fig 10.2 Line diagram of Diesel engine fuel system

**Filters**

Water and dirt must be removed from the diesel for which two filters are employed, primary filter in usually in the form of a coarse wire gauze and is often optional. It prevents large solid particles and water from going to the feed pump. Secondary filter is used after the fuel feed pump and is meant to remove fine particles of dust, dirt etc. From the diesel which is to go to the injection pump.

**Fuel injection pump**

From the fuel tank the fuel is delivered to the fuel injection pump by means of fuel feed pump. The rate of fuel delivery depends upon the engine requirements.

**Injector**

The function of the injector is to inject proper quantity of fuel into the engine cylinders at the correct time and at a predetermined rate. It is classified into the solid injection and the air injection system. In the solid injection system, only the liquid fuel is injected along with compressed air. The air injection system is less reliable and less efficient so the solid injection system is used in diesel engines.

**Two types of solid injection system are in use**

1. Common rail fuel injection system
2. Individual pump fuel injection system

**Air Cleaners**

As hundreds of cubic meters of air per hour are used by the engine of an automobile. This air should be very clean. Impurities like dust in the air cause a
very rapid wear of the engine particularly of the cylinder piston, rings, valves and guides. Further if the dirty air enters the crank case, it will contaminate the lubricating oil and ultimately damage the bearing and journal and decrease the service period of lubrication system. Therefore customary of install air cleaner on the intake system of automotive engines. Air cleaner also performs other function.

1. It reduced the engine induction noise to an acceptable level

2. In case the engine back-fires the air cleaner also acts as a flame arrestor. Air cleaners should be cleaned regularly or replaced periodically say every 20,000 K.M.

**The air cleaners generally used are of two types**

1. Heavy duty type
2. Light duty type
3. Thermostatic control air cleaner.

**Heavy duty type air cleaner**

![Fig 10.3 Heavy duty type air cleaner](image)

This is oil both type. It consist of a filler element C saturated with oil. At the bottom there is separate oil Pan D. The air from the atmosphere enters through circumferential gap A. At the corner B when the air takes a turn it leaves large particle impurities there next, impinging on the surface of the oil relives the air further of impurities. Final cleaning is done by means of filter C and the clean air passes through passage E as shown in Fig.
Light Duty types air cleaner

Fig shows a light duty type of air cleaner it consist of a cleaning element only the elements consist of a cylinder cellulose material over which is put a fine mesh screw to provide strength the elements is corrugated increase the surface area exposed to the incoming air so that the resistance offered by the air cleaner is reduced to minimum sides of the elements the element and any dust contained is left outside.

Thermostatic control of air cleaner

In modern engines, lean fuel air mixture is employed to reduce air pollution. However such as engine would not perform start or idling. To remedy this incoming air is heated and then sent to the air cleaner having a thermostatic control, sensitive to a spring which control an air bleed valve depending upon the temperature of the air entering the carburetor. When the engine is cold, the bleed valve starts opening as a result of which some cold air from the outside mixes with hot air thus decreasing its temperature. at about 40°C the bleed valve opening is maximum when the hot air supply is cut off and only outside air enters the carburetor.

10.3 FIP Timing

The timing of a fuel injected into the cylinder is very important during engine starting full load and high speed operation. Diesel engines start best when fuel is injected or very close to top dead center, since it is at this point that air in the chamber is the hottest. After the engine is started and running at high speed the injection timing may have to be advanced to compensate for injection lag, ignition lag, and other factors that influence combustion within the engine cylinder.

10.4 Engine idling speed adjustment

There is a idle adjustment screw provided in the carburetor screwing in the some decrease the idle part area and hence decrease the engine speed. The screw is adjusted till the engine runs smoothly at required speed. Generally this is done by screwing incompletely and them opening back by one or two turns. Another method for idle adjustment, which is precise involves attaching a vaccum gauge to the inlet manifold and adjusting the idle screw till maximum vaccum is obtained on the gauge.
10.5 Study of LPG as fuel for vehicles

Liquid field petroleum gas (LPG)

The lique field petroleum gas consisting mainly of butane and propane is also used as engine fuel. It is in liquid form in special cylinders at a pressure of about 100psi (700 kpa) and the engine is provided with a special fuel system.

Advantages of LPG are

1. Better mixing with air and improved distribution which means lesser emission.
2. No need of a fuel pump.
3. No carbon deposits.
4. Lesser oil consumption.
5. Less engine wear.

Disadvantages

1. Special fuel system has to be provided.
2. Heavy pressure cylinders increase the vehicle weight.
3. Harder to start in winter.

How do LPG and natural gas cars work

Both LPG and natural gas can be used in a modified spark – ignition (petrol) engine. These gases make ideal fuels of combustion engine due to their high octane rating, low levels of volatile organic compounds and the fact that they can readily mix with air prior to combustion. These characteristics result in a more complete combustion, which helps to reduced exhaust emissions. The gas clean burning characteristics also reduce engine stress, therefore extending engine life.

Due to limited availability of these fuels, most gas adapted vehicles are bi-fuel conversion, able to operate on either gas or petrol; the fuel being selected at the flick of a switch. Modern conversion use electronically controlled gas injection system which allow optimized performance from either fuel type.

The most significant difference between gas and conventional cars is the method of fuel storage while both LPG and natural gas are gaseous at room temperature and pressure, LPG can be easily liquefied under pressure which makes it the more popular of the two ‘Rod gases’. The steel tanks most commonly
used to contain the fuels under pressure the fuel can add up to 60kg to a vehicle's weight and in the case of bi-fuels cars, can reduce over all fuel consumption as two fuel tanks are required.

Driving an LPG and natural gas car is similar to using a conventional car. The main additional control is a switch, usually located by the gear lever or on the dashboard, which enables the driver to select LPG or petrol operations and a dual-mode fuel gauge. Regarding performance drivers of BI-Fuel cars may notice a small loss of power at full throttle when in gas fuel mode. Both LPG and natural gas are tired and tested green car fuels.

**Before installing the LPG into vehicle**

- Check the overall vehicle condition
- Check the condition of your engine and petrol system
- Determine which type of installation is appropriate for the vehicle.
- Locate the points where the electrical system is connected see the wiring diagram of the vehicle
- Select the gas tank and determine the location of its mounting
- Designate the location for a gas refusing valve
- Determine the location for the controller installation
- Designate the location in the cab where the LED switch board should be mounted
- Determine the location for mounting the pressure regular and the injector
- Disconnect the vehicle battery
- Start the installation process

![Fig 10.4 LPG fueled system](image)

Fig 10.4 LPG fueled system
10.6 Study of CNG driving vehicle

Compressed Natural Gas (CNG)

Natural gas consists mainly 95% of methane (\(\text{CH}_4\)) remaining 5 percent comprises butane, propane, ethane with small amount of water vapour. Simple chemical structure of methane makes possible its nearly complete combustion releasing lesser emission.

For ease in transportation, storage and automotive use, the natural gas is compressed and stored in high-pressure cylinders, that is why it is called compressed natural gas.

Advantage of CNG used as a fuel

1. Very low emission compared to petrol. CNG combustion produces about 25% less CO\(_2\) and does not produce greenhouse gases.
2. It requires no additives.
3. It saves the petroleum resources.
4. CNG has very high knock resistance.
5. Due to the absence of any lead or benzene contents in CNG the lead fouling of spark plugs is eliminated.
7. CNG fuel systems are sealed, which prevents any spill or evaporation losses.
8. Increase life of lubricating oils.
9. Less pollution and more efficiency.

![Fig 10.5 CNG driving system](image)
1. The drawback is compressed natural gas vehicles required a greater amount of space for fuel storage.

### 10.7 Study of Air Conditioning

The aim of air conditioning is to control the temperature and humidity of the atmospheric air and circulate the same in the automobile so that a comfortable feeling is obtained by the passengers.

The automobile air conditioning system consist of

1. Refrigeration system
2. An air circulation and distribution
3. A control system.

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**Fig 10.6 Layout of refrigeration system for car air conditioning**

The system includes the compressor condenser, evaporator, receiver-dehydrator and connecting lines besides one or more of the following depending upon the design of the system. Expansion valve, orifice tube, suction throttling valve, positive operating absolute valve, evaporator, pressure regulator valve, temperature tube, (Thermal sensor) high pressure cut off switch and cycling compressor switch.

The refrigerant “R 134 a”, vapor from the evaporator is compressed to high pressure by the compressor which is driven by means of a belt from the engine pulley through an electromagnetic clutch. The high pressure refrigerant vapour from the compressor is then discharged to condenser. Air is caused to
flow across the condenser by ram air while driving and by the action of the engine fan or electric. Fan cooling of the refrigerant vapour in the condenser converts it into liquid still at high pressure.

This liquid is then collected in a receiver from where it is passed through a dehydrator to extract any moisture. Dry refrigerant liquid is then made to pass through expansion valve mounted at the inlet side of the evaporator. The expansion valve allows the refrigerant liquid to expand to low pressure in the evaporator. The process of expansion to low pressure makes the refrigerant to evaporate and thereby cool the evaporator. A sensing device called temperature tube signals the diaphragm in the expansion valve to vary its orifice size depending upon the refrigerant temperature at the evaporator outlet. Thus achieving automatic temperature control.

The control in the air conditioning system are the temperature control, mixing of air control and the selection of the cooling air to the desired outlet. Fully automatic temperature control system is microprocessor based and depending upon input signals i.e. outside air temperature, inside air temperature mode selection and desired temperature setting automatically control the air mixer valve recirculation valve and the defrost valve.

**Benefit of co₂ as a refrigerant**

(a) Environment benefits

(b) 20% less fuel consumption

(c) Smaller compressor

**Maintenance of car A.C system**

1. Clean the condenser during normal servicing
2. Maintain correct refrigerant level
3. Top up the compressor with adequate oil
4. Clean the evaporator periodically
5. Maintain proper belt tension

**Precautions**

1. Do not use AC with fresh air mode open always
2. Never operate AC with heater on
3. Never run AC without refrigerant
4. Do not leak – test AC with more than 2 mpa pressure
5. Do not leave AC joints open which may cause the moisture to enter the system

**Summary**

- A fuel pump is used to deliver fuel from the fuel tank to the float chamber of the carburetor.
- The modern filtration practice employs a combination of coarse and fine filters.
- The carburetor is a device for atomizing and vaporizing the fuel and mixing it with air in varying proportion to suit the charging condition of the engine.
- The function of the injector is to inject proper quantity of fuel into the engine cylinder at the correct time and at a predetermined rate.
- The aim of air conditioning is to control the temperature and humidity of the atmospheric air and circulate the same in the automobile.
- Never operate AC with heater on.

**Short Answer Type Questions**

1. Write the types of fuel pumps.
2. Write the types of air cleaner.
3. Explain FIP timing.
4. Explain Idle speed adjustment.
5. What are the gases present in the CNG?
6. Write the disadvantages of LPG used in car.
7. What is the aim of air conditioning in cars?
8. What are the benefit of CO\textsubscript{2} as a refrigerant?
9. Explain maintenance of car AC system.
10. Write the precautions to be taken while using car A.C system.

**Long Answer Type Questions**

1. Draw petrol engine vehicle line diagram and explain the parts.
2. Draw the Diesel engine vehicle line diagram and explain the parts.
3. Explain the function of Air Cleaner.
4. Write the advantages and disadvantages of CNG.
5. Draw the layout of LPG system fuel supply system for petrol engine.
6. Explain the “Air conditioning” in cars.

**Practical Questions**

1. Study of fuel feed system.
2. Petrol pump overhauling.
3. Dismantling the carburetor.
4. Dismantle and clean the filter and air cleaners.

**O.J.T**

1. Identifying main defects in fuel fed system and rectify them.